Frontiers in Fluid Mechanics (A collection of Research papers written in Commemoration of the 65-th Birthday of Stanley Corrsin)
edited by St H Davis and J L Lumley
Springer-Verlag : Berlin-Heidelberg-New York-Tokyo, 1985
340 pages, 132 figures ; price : DM 90 (Hard cover) ; ISBN 3-540-15361-6

This book is a collection of twelve research papers written in commemoration of the 65th birthday of the great fluid dynamist Stanley Corrsin of Johns Hopkins University. The papers are written by leading scholars of fluid mechanics and are mainly on various problems of turbulence. As our understanding of the phenomenon of turbulence is far from satisfactory and most of the papers of this volume deal with suitable experimentation and numerical simulation necessary to upgrade our understanding of the phenomenon through building of better analytical models the volume has been rightly named as 'Frontiers of Fluid Mechanics'.

In the first paper, Penven and his co-authors attempted experimentally and numerically to understand the effect of unequal kinetic energy partition among different fluctuating velocity components on approach to isotropy of homogeneous turbulence. They observed that the return to isotropy was slow when only one velocity component was energetic, while it was faster when two components were energetic. However, their work was limited to irrotational strains only. Other cases of interest need further investigation. The second paper by Karweit deals with extension of the concept of random walk. To study dispersion, they used the concept of walk on a random field using discrete fields as tools. It is a first attempt in this direction and requires further attention in the light of the fact that the ideas can be applied in other areas like flow of long-chained polymers. In his paper, Sreenivasan examined the applicability of results on low-dimensional chaos theory to explain transition to turbulence in flows behind a circular cylinder by comparision with suitable experimental results. Possibilities and limitations of such applications were also discussed by him. Herring's paper exposed vividly the limitations of two-point closure theory for representing several turbulent flows. From the idea of conditional moments Kollmann introduced the concept of 'conditioning' to study intermittent flows and examined several application to show that conditional information could be extracted from experimental and numerical simulation and closure models for turbulent shear flows could benefit from these results.

O'Brien proposed a closure model which was appropriate for numerical study of the spectrum of a single chemically reactive species in homogeneous turbulence

to predict the effect of moderate rate kinetics. His approach arouses hopes but it requires further investigation. In their paper Riley and Gad-el-Hak presented a critical review of the present state of knowledge on turbulent spots and their applications. Phillips' paper deals with the study of spectral and statistical characteristics of breaking waves necessary for finding critaria to predict breaking of waves. Gibson, in his paper, discussed the effect of streamline curvature on turbulence using anology between streamline curvature and buoyancy along with suitable modelling of second moment equation. Lumley and Cruyningen presented an in-depth discussion on the problems faced while modelling passive scalar diffusion in the atmosphere and the ocean and finally indicated the successes and limitations of second order modelling.

The other two papers by Rosenblat and Davis, and Margulies and Schwarz are of different nature. In the first of these spreading of liquid drops on solids was discussed and it was shown that capillary push and contract-line spread were the main controlling factors for Newtonian liquids, while for non-Newtonian fluids shearthinning was more important in cases where lubrication approximation was applicable. The second one dealt with theoretical extension of results on propagation of acoustic waves through various types of fluid mixtures. Exact solutions were obtained and it was shown that these could be utilised as aids complementing experimental approaches to test constitutive equations and measure physico-chemical parameters.

In addition 'Dedication' by Davis and Lumley at the very beginning of the volume gives an excellent account of the contributions of Corrsin which will surely encourage young researchers in their future persuit.

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Boundary Value Problems in Linear Viscoelasticity

by J M Golden and G A C Graham

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xiv+ 266 pages, 13 figures ; price : DM 120 (Hard cover) ; ISBN 3-540-18815-8

The book is written mainly for applied mathematicians dealing with viscoelasticity. The chapter one is aimed at introducing the basic principles and conceptual tools necessary to study problems of viscoelasticity. Begining with one-dimensional linear heridity constitutive equations, it includes the special case of

non-aging material using linear functions. Creep and relaxation phenomenon have been dealt with taking energy consideration and Boltzman superposition principle into account and neglecting the dependence on temperature. Temperature dependent viscoelasticity functions have been considered in a small sub-section in this chapter. The chapter ends with a discussion on three dimensional constitutive and dynamical equations with special emphasis on the case of materials which are mechanically isotropic.

In chapter two, the methods of solution applicable to study boundary value problems necessary for investigating the behaviour of viscoelastic materials have been developed in a general way for non-inertial cases only. Special attention has been paid for regions having time dependent boundary.

The methods developed in chapter two, have been applied in chapter three to study iso-thermal contact and crack problems. All types of boundary value problems have been considered but special attention has been paid to plane non-inertial contact problems and moving load problems.

Chapter four is entirely devoted to study plane non-inertial cracks of both stationary and growing type while chapter five deals with three-dimensional contact problems to include both varying load problems and impact problems.

A special problem of thermovisco-elasticity has been presented in chapter six. A simple case has been presented only to demonstrate the complexity of the general case and to provide with a taste of such problems.

Similarly plane contact and crack problems including inertial efforts have been investigated in chapter seven. These plane problems amply illustrate the difficulties of studying inertial problems in general. The exposition in this chapter, also establishes the need to study more problems in the area which are current topics of research to-day.

A perfect balance between mathematical rigour and intuitive/heuristic arguments have been maintained throughout the book so as to make it readable to all types of readers. Useful exercises will be of much help for those intending to work in the area and summaries provided at the end of each chapter will be useful as ready reckoners for established workers.

As there does not exist any book of this kind in the present literature this will serve a great purpose for new and established research workers in the concerned area.

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Derivation of Hilbert Space Structure (An Axiomatic Basis for Quantum Mechanics, Vol 1)
by G Ludwig

Springer-Verlag : Berlin-Heidelberg-New York-Tokyo, 1985
x+243 pages, 6 figures ; price : DM 118 (Hard cover) ; ISBN 3-540-13773-4

The book under review is the first volume of a two-volume work, which is an expanded version of the review work that appeared in German (Notes Math. Phys. 16, 17, 18, Marburg, 1980) and it intends to supplement the previous book by the same author entitled Foundations of Quantum Mechanics, Volumes I and II (Texts and Monographs in Physics, Springer, Eerlin, 1983). The principal motivation underlying these efforts of the author is to develop a self-consistent axiomatic basis for quantum mechanics which would help to demystify some of the key interpretational and conceptual problems of quantum mechanics, like the quantum measurement problem. Of course, this motive concerns primarily the philosophy of science and is linked with the question of the best possible "understanding" of quantum mechanics. However, in recent years, many of these basic questions have been catapulted from the domain of metaphysics into that of experimental physics ; for example, the subtle aspects of the quantum measurement problem have been subjected to critical empirical scrutiny through the experiments with single-crystal neutron interferometers.

The present book adopts an approach which is too abstract and formal. It doesn't help to provide easy physical insights into the niceties of these problems and their empirical relevance is left out of the ambit of the discussions. Nevertheless, for the mathematically minded ones this book provides an interesting reading. In the first four chapters the author outlines systematically the mathematical structure for the axiomatic basis of quantum mechanics. In the process he discusses the pertinent mathematical details related to the topologically complete vector spaces. In this connection, the reviewer found his analysis of some convergence theorems in Chapter IV and discussion of composite macro-systems in the trajectory space (Ch. III) to be quite incisive. In Chapter V, the author introduces the notion of observables through the idea of Eoolean Rings. The exposition there-in is very difficult to grasp. Consequently, the Chapters VI and VII tend to be a confusing array of abstract theorems far removed from the physical world of quantum mechanics. The redeeming features in these chapters are the remarks on the relations between preparation and registration procedures (p 164), commensurable decision effects (p 172), and system types and super-selection rules (p 205). These remarks may be useful for the one already conversant with the nuances of the foundational problems of quantum mechanics.

In particular, the discussion on super-selection rules is from an unorthodox point of view and the reviewer found it to be amenable to further critical thoughts.

The final chapter of the book contains a mathematically brilliant exposition of the representation by Banach Spaces of Operators in a Hilbert Space. It should be instructive to anybody interested in the algebra of Banach Spaces, independent of whether he or she is concerned with the foundational problems of quantum mechanics. In particular, the reviewer found the discussions of the relevant topological properties and the representation theorems to be rather illuminating. There is a brief discussion on pp 221-222 regarding commutability of operators ; in this context it would have been very helpful if the relationship of this mathematical framework with the physical content of the uncertainty principle was more elaborately explained.

In conclusion, the reviewer hopes that the forthcoming second volume of this book will make clear the physical implications of the author's approach and how it actually tackles the conceptually delicate foundational issues of quantum mechanics.

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Special Functions of Mathematical Physics : A Unified Introduction with Applications

by Arnold F Nikiforov and Vasili B Uvarov (Translated by Ralph P Boas)

Birkhäuser : Basel-Boston, 1988
429 pages ; price : SFR 168·00 ; ISBN 0-8176-3183-6

Physicists cannot do without special functions. They appear in mathematical description of all sorts of physical phenomena. In spite of that, their theory remained rather cumbersome, requiring special tricks and complicated ideas. This book aims to remove these obstacles and present the theory of special functions for physicists in terms of very simple and very general ideas. The unique organizing principle, which makes the book very readable, enjoyable and profitable is stated succinctly in the sub-title : 'A Unified Approach with Applications'. The elegance and comprehensibility of this unified approach makes the logical interconnections and relations between the different functions very clear. The ease with which this approach is applied to physical problems is a major attraction of this volume. The derivations, formulas and proofs of theorems require careful attention but are manageable with introductory calculus and complex analysis.

Starting with a differential equation of the hypergeometric type (defined in the very first page), the authors derive a generalized Rodrigues' formula for its solution. This involves a weight function, which, in its turn, is derivable from the polynomial coefficients of the differential equation. All properties of the solutions, like explicit integral representations, asymptotic formulas, generating functions, generalized recursion relations, series expansions, orthogonality, closure and completeness follow. By using coefficients with prescribed forms we obtain Jacobi polynomals (and the Legendre, Chebyshev and Gegenbauer polynomials as special cases) and the Laguerre and Hermite polynomials as specific solutions. These are the classical orthogonal polynomials arising in eigenvalue-problems and it is shown how quantum mechanical problems directly lead to these polynomials. Spherical harmonics have been treated in great detail and explicit expressions for the finite rotation matrix-elements have been derived.

The most novel feature of the book is the treatment of orthogonal polynomials of a discrete variable on uniform and nonuniform lattices. The authors claim that this is the first time this theory has been incorporated in a book. Once again, the basic idea is simple. It is apparent that when the differential equation is replaced by an analogous difference equation, the solutions of this equation possess properties which are finite difference analogues of those of the corresponding solutions of the differential equation, and converge to them in the limit of small differences. Thus without any special tools, a complete theory of classical orthogonal polynomials on a discrete lattice can be constructed. For example, a finite difference Rodrigues' formula with weight factors satisfying finite difference equations leads to Hahn, Meixner, Kravchuk and Charlier polynomials. Their analogues on nonuniform lattices with quadratic and other spacings can also be constructed. It seems strange that these results, so easily obtained, can be so unfamiliar.

One full chapter has been devoted to Bessel functions. This includes a thorough analysis of semiclassical WKB approximation and its application to the solution of Schrodinger equation in central fields.

From a physicist's point of view the last chapter on applications (mostly quantum mechanical problems) is extremely interesting and well written. The integrated approach of the earlier chapters enables one to solve all the basic quantum mechanical problems elegantly. Of particular interest is the treatment of Schrödinger, Klein-Gordon and Dvac equations in Coulomb field. In another impressive section, the authors show simple connection between Clebsch-Gordan coefficients and the Hahn polynomials and discuss 6-j symbols through orthogonal polynomials of a discrete variable. All these results are, of course, very unfamiliar.

Only a few of the topics treated in the book have been mentioned above. The book requires careful study, because it is only after such a study that the whole design becomes clear and a proper appreciation of its contents is possible. For quick reference the appendix contains a list of the basic formulas.

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Physics of Highly Charged Ions (Springer Series in Electrophysics, Vol 13)
by R K Janev, L P Presnyakov and V P Shevelko

Springer-Verlag : Berlin-Heidelberg-New York-Tokyo, 1985
x+330 pages, 93 figures ; price : DM 148 (Hard cover) ; ISBN 3-540-12559-0

In a paper published in 1929, Dirac made the following interest comment : "The underlying physical laws necessary for the mathematical theory of a large part of physics and the whole of chemistry are thus completely known, and the difficulty is only that the exact application of these laws leads to equations much too complicated to be soluble". The field of atomic physics is covered by the 'large part of physics' mentioned in the above statement but the atomic physicists are still struggling to overcome the 'only difficulty'. While their arsenal is now considerably equipped with the development of high-speed computers having large memories, the targets are extended over a large area and new goals are being added a man's interest in subjects like plasma physics, laser physics, fusion research and astrophysics continues to grow. Highly charged ions play important roles in a wide variety of phenomena that fall under the jurisdiction of these subjects and the present and the last decade are marked by an enormous growth in research attempting to understand these roles. Janev, Presnyakov and Shevelko in their book 'Physics of Highly Charged Ions' deal with several aspects covering highly charged ions, like their structure and spectra, radiative processes involving them and their behaviour while undergoing collisions with electrons, ions, atoms and molecules. The book covers primarily the theoretical methods, reference to experiments being made mainly for comparison with theory.

A major part of the book is concerned with the collisions between highly charged ions and heavy particles like ions, atoms and molecules. The theoretical methods that are currently in use for investigating excitation, ionization and electron capture processes in such collisions are clearly explained in this part. The successes and failures of different models and approximations have been critically analysed in

the light of experimental evidences. The part dealing with electron-impact excitation and ionization of highly charged ions is relatively short but the characteristic features of the processes have been discussed and explained. There is only one chapter on the structure and spectra of highly charged ions where the authors had to take a descriptive approach. The last chapter deals with the rate coefficients for electron-impact excitation and ionization, photo recombination, di-electronic recombination and charge transfer, and contains useful tables and graphs.

The book will be a welcome addition to an atomic physicist's bookshelf and of much use to researchers working on highly charged ions.

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Trends in Applications of Mathematics to Mechanics

(Proceedings of the 7-th Symposium, held in Wassenaar, The Netherlands, December 7-11, 1987)

edited by J F Besseling and W Eckhaus

Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo-Hong Kong, 1988
ix + 361 pages, 62 figures ; price : DM 88 (Hard cover) ; ISBN 3-540-50075-8

The book in question is the Proceedings of the 7-th Symposium on 'Trends in Applications of Mathematics to Mechanics' held biennially under the auspices of the International Society for Interaction of Mechanics and Mathematics. The 7-th Symposium was held in Wassenaar, The Netherlands in December, 1987.

Out of the total of 35 lectures delivered at the Symposium, 33 papers have been published under five sections namely,

a. Perturbation Methods in Application,
b. Instability, Bifurcations and Transition to chaos,
c. Multibody Dynamics and Control,
d. Mechanics and Mathematics of Non-Classical Materials,
and e. New Interactions of Mathematics and Mechanics.

The papers under the above sections cover a wide range of classical and also topical problems in mathematics and mechanics using and extending the available mathematical methods. As for instance, the fields of applications included are : thin cellular structures, magnetomechanical signal processing devices, problems in hydrodynamics robotic manipulators, viscoelasticity, etc. to mention a few of the important ones.

Again, the present volume being the proceedings of an important symposium, one would expect that the salient aspects of the discussions and observations made by the leading experts should have been incorporated. These, unfortunately, are missing. Otherwise, the volume would be useful to scholars and researchers working in the field of mathematics and mechanics in general.

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Geometry of Supersymmetric Gauge Theories (Including an Introduction to BRS Differential Algebra and Anomalies) (Lecture Notes in Physics, Vol 302) by Francois Gieres

Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo-Hong Kong, 1988
viii + 189 pages ; price : DM 34 (Hard cover) ; ISBN 3-540-19080-5

The notes by F Gieres on the geometry of supersymmetric Yang-Mills' theories are on a very specialised topic and useful to the specialists. The inclusion of detailed account of BRS differential algebra fill a gap towards full quantized theory. The notes are mathematical and little physics could be expected in very nature of the topic chosen. However a creditable effort is made to draw analogy to physical aspects of well established theories in the description of classical Yang-Mills' theories in real gauge representation. The appendices make several notations and conventions clearer. The equations, though filled with hand, are quite legible. The notes fill a gap between the beginner's level and that of a specialist wanting to begin with quantum supersymmetric Yang-Mills' theory.

One may still ask the question posed by the author in Ch. II 'what is the use of all this ?' Perhaps it is too early to ask this question as the question of physical implications of these novel theoretical edifies is quite open.

In all, the book is a notable attempt in filling the gap in the understanding of the supersymmetric space with non-abelian fibre bundles and a must for the student specialising in research in these fields.

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Foundations of Quantum Mechanics II (Texts and Monographs in Physics)
by G Ludwig

Springer-Verlag : Berlin-Heidelberg-New York-Tokyo, 1985
xvi + 416 pages, 54 figures ; price : DM 228 (cloth) ; ISBN 3-540-13009-8

This is a remarkable book, thorough in its exposition, novel in its interpretation and highly deductive in its coverage. Professor Ludwig, as is well-known, is a pioneer in the field. According to one of his famous students, Professor Kummel, he was a champion in both propounding and emphasizing the highly non-trivial aspects of the foundations of quantum Mechanics. The present volume is the part II of the monumental two volume Grundlagen series, written in German. The English translation by Carl Hein is admirable. Chapters IX to XVI cover more or less the standard topics-ranging from representation of Hilbert Spaces by Function spaces, equations of motion, spectra of one, two and many-electron systems, foundation of scattering formalism etc. They are, however, presented from a highly developed, axiomatic and unified point of view. The chapters XVII and XVIII are real gems where respectively the preparation/measurement processes and Quantum Mechanics and Macrophysics are discussed in depth with great originality and lucidity. The book is a very welcome and timely translation of a classic series in the field.

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Non-Equilibrium Dynamics in Chemical Systems (Springer Series in Synergetics, Vol 27)

(Proceedings of the International Symposium, Bordeaux, France, September 3-7, 1984)

edited by C Vidal and A Pacault

Springer-Verlag : Berlin-Heidelberg-New York-Tokyo, 1984
x + 255 pages, 137 figures ; DM 75 (Hard cover) ; ISBN 3-540-15065-x

This book embodies the papers presented in the proceedings mentioned in the title-heading. The topics covered are quite diverse-ranging from oscillations, multistable systems, chaotic evolution to nonequilibrium chemical systems. As the editors point out, the articles represent the-then state-of-the-art of the field of nonlinear dynamics, although the rapid advances in this discipline have made many of these rather back-dated. But even then, an expository article by Haken on

spatial/temporal patterns for systems far from equilibrium and the articles on oscillating reactions by Epstein, Pifer *et al*, on noise-induced transitions by Horthemke, and on Stochastic evolution by Nicolis retain their pedagogical and research values to date. Most of the articles, however, are rather too brief to be of educative value. They serve to announce the on-going projects meant for the experts in the field.

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